SPATIAL AND TEMPORAL EFFECTS OF ORGANIC ENRICHMENT ON MEIOBENTHOS

by

John Henry Moverley BSc (Qld) MSc (Qld) MAIBiol

Submitted in fulfilment of the requirements

for the degree of

Doctor of Philosophy

UNIVERSITY OF TASMANIA

HOBART

January, 1995

STATEMENT

Except as stated herein this thesis contains no material which has been accepted for the award of any other higher degree of graduate diploma in any tertiary institute. To the best of my knowledge and belief this thesis contains no copy or paraphrase of any material previously published and written by another person, except where due reference is made in the text

John Henry Moverley

ABSTRACT

Meiofauna assemblages were studied along putative organic enrichment gradients at two marine salmon farms: Loch Ewe, Scotland, U.K. and Nubeena, SE Tasmania, Australia; and a sewage outfall: Sandy Bay, SE Tasmania. The broad objective was to identify any general meiofauna responses to organic enrichment.

1. No evidence of parallel meiobenthic communities (the same genera occurring at different geographical locations in environments with similar environmental conditions) was found in areas of high organic input.

2. Nubeena was the only site where a "classical" pattern of community response to organic enrichment was found. Severe enrichment (sediments are organically rich and anoxic zones are near the surface; nematodes and annelids can be found; other taxonomic groups, e.g. harpacticoids, are rare) existed under the cage centre. Moderate enrichment (sediments have slightly elevated organic content and anoxic zones may, or may not, be close to the surface; annelids, nematodes, and harpacticoids are present, though numbers of taxa are reduced and densities may vary from depauperate to population blooms, i.e. densities one or two orders of magnitude above normal) occurred from under the cage periphery out to 5 m. Slight enrichment (sediment changes are difficult to detect, densities and species richness are elevated and there are abnormal species abundance patterns) occurred from 10 to 20 m.

3. At Loch Ewe, severe enrichment occurred under the cage periphery. The region 10 to 25 m from the cage appeared to be moderately enriched, with slight enrichment out to 100 m. This contradicts the results of macrobenthic and physico-chemical surveys that have never indicated effects extending more that 50 m from Scottish salmon cages.

4. The Loch Ewe meiofauna assemblages were markedly different to those from Nubeena because no population blooms were detected and no harpacticoid genera were limited to the area of highest

organic enrichment. Population blooms may have been missed because they are a seasonal phenomenon, or because the moderately enriched zone occurred between two sampling sites. Differences in harpacticoid distributions at the two locations are probably because of the background organic content which was high at Loch Ewe and low at Nubeena.

5. At Sandy Bay, there was a sharp demarcation in sediment structure and meiofauna assemblages 20 m from the sewage outfall. It is reasonable to assume that the sewage effluent was responsible for the sediment modification and therefore the faunal changes. Compared to sites > 20 m from the outfall, sites close to the outfall had a different nematode species composition; fewer nematode taxa; and a depauperate harpacticoid assemblage. Nematode densities were similar at all sites.

6. At a Nubeena cage site, recovery changes in the meiofauna were monitored for six months after the fish had been removed. Neither nematodes nor harpacticoids showed a full recovery over the period. No change in the organic content of the sediment was detected. Benthic oxygen uptake measurements indicated it would take more than 18 months for the physico-chemical environment to return to normal.

7. Nematode population changes were gradual and there was a trend for assemblages at different enriched sites to converge. Changes in morphological types were apparent. When the cage was stocked, Type 1a nematodes (buccal cavity small, no armature) made up the greatest proportion of the assemblage. After cessation of organic input, these decreased and Type 2a (buccal cavity medium sized, armature as small teeth) increased; while later in the recovery Type 2a decreased and Type 1b (buccal cavity medium sized, no armature) increased. This pattern could be detected along temporal and spatial gradients from the organic input source.

8. Harpacticoids experienced rapid population fluctuations with numerically dominant taxa changing in the space of weeks. When

the cage was stocked the harpacticoid assemblages at the enriched sites were similar and consisted mostly of epibenthic taxa. In later samples the interstitial taxa increased and the assemblages tended to diverge. This is probably caused by spatial differences in the rate of recovery of subsurface sediments.

9. Among nematode and harpacticoid assemblages, density and number of genera were more sensitive to organic enrichment than Evenness or Shannon-Wiener diversity. Contrary to many other studies described in the literature, Evenness tended to be high at severely enriched sites decreasing to minimum but extremely variable values in the moderately enriched zone.

10. Harpacticoids were not very sensitive when comparing sites in highly enriched zones, due to high between-replicate variability. Neither harpacticoids nor nematodes were very sensitive when comparing sites in areas of mild disturbance and thus were not useful for delineating the precise area affected by enrichment. However, by combining data for the two taxocenes with that for other components of the fauna e.g. macrofauna, greater sensitivity could be obtained.

11. If monitoring is restricted to a single taxocene, a multivariate method which determines associations of taxa and their distributions is more sensitive for detecting changes in environmental conditions than site classification. This method gave similar results to those obtained by combining all data in a site classification.

ACKNOWLEDGMENTS

The project would not have been possible without the assistance of Trioxide Pty Ltd who, to promote ecological work with meiofauna in Australia, conceived the idea and provided funds so that an Australian could travel to the United Kingdom to learn techniques for working with, and identifying, meiofauna; and so that Dr. Richard Warwick could travel to Australia to promote meiofauna work. Without Trioxide the project would not have been possible.

I wish to thank my co-supervisors Dr. Richard Warwick and Dr. David Ritz. I owe much to them for their patience and continued interest over this project. I particularly like to thank Dr. Ritz, for the innumerable ways that he assisted me and particularly for his critical comments on the thesis.

Dr. Warwick assisted by enlightening me on the techniques of nematode identification, and providing literature to me. Also, when possible he made the facilities of the Plymouth Marine Laboratories available to me and provided critical comments on the thesis.

I would also like to thank Dr. Warwick for his indirect assistance as editor of Psammonalia, which was a great assistance by keeping me in touch with the meiobenthic "community". As well I thank the other people who were involved in the production of Psammonalia.

I am deeply indebted to the management and staff of the Plymouth Marine Laboratory for providing facilities and their hospitality during my visit. I am particularly indebted to: Dr. Mike Gee for assistance in instructing me in the methods of harpacticoid identification, and making literature available to me. Dr. Martin Carr and Dr. Bob Clarke for making the PRIMER software available to me.

I am indebted to Tassal Pty Ltd, formally Safcol Fisheries, who allowed access to their fish farm lease and on occasions made boats and staff available to assist with field work. I would particularly like to thank Anthony Forester who acted as the point of liaison with Safcol.

I wish thank John Davies and Derrick Murison of the Department of Agriculture and Fisheries for Scotland for making Loch Ewe samples available and their hospitality during my visit to Scotland.

I am also indebted to The Division of Sea Fisheries, Tasmania for making the benthic respirometry chamber available. To Dr. Barry Gallagher who originated the benthic respirometry work and made available to me his data analysis methods and programs so that we could have comparable results. Mike Rushton who taught me how to use the benthic respirometry chamber and assisted with some of the field work.

The Bureau of Meteorology for making weather data from Palmer's lookout during the period December, 1989 to June 1990 available.

CONTENTS